People - Carson, Rachel

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THE DEADLY DUST: The Unhappy History of DDT

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Everyone knows a little about the rise and fall of DDT—how it was once hailed as a great boon to mankind; how useful it was in field and garden, house and yard; and how at last to our dismay it was unmasked as a killer, the chemical Al Capone, a threat to our environment and possibly our very existence. Everyone knows that the federal and state governments are acting to end the DDT menace, saving us, if narrowly, from disaster. We can breathe easy again. . . . Or can we?

The history of DDT is well worth pondering, for its fatal implications extend to the whole of our civilization. The central character of the story is, of course, the chemical compound itself. But there are also two human protagonists—a chemist in Switzerland and a marine biologist in the United States—and our story begins in 1936, a year of crucial career decision for each of them.

The chemist, Dr. Paul Herman Mûller, was thirty-seven years old that year, an employee of the great dye-manufacturing firm of J. R. Geigy, S.A., of Basel. As a remarkably skillful and creative laboratory technologist, he had developed a number of synthetic tanning substances; by 1936 he had turned his attention to pesticide research.

Also in 1936 a short, slender, solemn-faced woman, twenty-nine years old and single, was teaching in the zoology department of the University of Maryland. In her student years she had majored in English composition as well as biology, followed by postgraduate work at the Marine Biological Laboratory in Woods Hole, Massachusetts. Now her desire to write moved her to accept a position in the U.S. Bureau of Fisheries (soon to be the Fish and Wildlife Service) offered her that year. When the school year ended, her name was listed on the U.S. civil service rolls: "(Miss) Rachel Carson, aquatic biologist. ..."

Meanwhile, Dr. Müller's pesticide research was leading to quick results. Within a few years he had invented two new insecticides, trade-named Gesarol and Neocid; their specific toxic ingredient, however, remained mysterious to him. In 1939, in search of this specific, he synthesized a chlorinated hydrocarbon whose unabbreviated chemical name is dichlorodiphenyltrichloroethane. Müller soon dubbed it DDT. He also soon learned that he was not the first man to make it. Back in 1874 a German student named Othmar Zeidler, working toward a doctor's degree, had synthesized it as an exercise in pure chemistry. But Zeidler had no notion how, if at all, the new compound could be used.

Not until Müller took some of it home with him one day and tried it out on houseflies did anyone realize that DDT kills insects. It was, indeed, the toxic ingredient of the two earlier insecticides Müller had compounded. And he soon found ways to make it even more potent.

By that time World War II had begun, and during its opening months Müller, having already proved DDT's effectiveness in controlling Colorado potato beetles on crops, found it equally effective in destroying lice on war refugees.

With each test, his and his firm's excitement grew. They became convinced that he had discovered the most powerful synthetic insecticide then known—fatal on contact in extremely minute quantities to an incredibly wide range of insects, yet apparently wholly nontoxic to man. Geigy quickly patented the formula (1940) as a general insecticide, and the manufacture of DDT began.

The patent descriptions were sent to Geigy's branches in Britain and the United States and, through them, made known in early 194210 British and American entomologists, who read the patents with mingled hope and skepticism. Of immediate concern to them, because of the millions of Allied army and navy personnel spread around the world, was DDT's possible use for control of malaria (carried by anopheles mosquitoes), epidemic typhus (carried by body lice), and dysentery and typhoid fever (both carried by houseflies). With growing desperation they had been searching for a substitute for pyrethrum, a contact insecticide extracted from a flower and, before the war, imported chiefly from Japan. War with Japan cut off the major source of supply just as the demand for pyrethrum soared. Allied doctors and sanitation engineers began to have nightmares about losing the

war to germs that could kill more people than all the bombs and bullets imagined in prcatomic years.

Urgently needed was the kind of synthetic contact insecticide—easy and safe to handle, capable of being economically mass-produced—which DDT seemed to be. British and American scientists were quick, therefore, to begin testing. Geigy's claims, which had at first seemed wildly excessive, were soon verified. With the War Production Board encouraging its manufacture, DDT production was approaching its wartime maximum of three million pounds a month by the time it was placed on Army supply lists in May, 1943, and on Navy lists in January, 1944. All DDT was allocated to the armed services save a few hundred thousand pounds for further experiments. Among these were field tests in which DDT in powder form was successfully used, in 1943, to arrest small typhus epidemics in Mexico, Algeria, and Egypt.

The Egyptian work was done under the supervision of the American Brigadier General Léon Fox, a field director of the Typhus Commission headquartered in Cairo. It was Fox who was summoned to newly captured, refugee-swollen Naples in late 1943, where Allied medical authorities saw that a major typhus epidemic was in the making. New typhus cases in the city approached sixty a day, and people were dying by the score everywhere, even in the gutters. If the epidemic followed the age-old pattern, there would be an explosion of death, with perhaps as many as 250,000 fatalities. In mid-December, the general and his men began a systematic dusting of the entire Neopolitan population with DDT. Within a month the number of new cases per day was in sharp decline. By mid-February there were no new cases at all. For the first time in history, in winter (typhus is a winter disease), under filthy, overcrowded conditions perfectly suited to it, a well-advanced typhus epidemic was not only arrested but, in a few weeks, totally eliminated. And this was but the beginning of DDT's march to glory.

Soldiers and sailors by the million carried small cans of DDT powder to protect themselves against bedbugs, lice, and mosquitoes. They came to love the stuff, especially in the tropics. Millions of DDT aerosol bombs were used to spray the interiors of tents, barracks, and mess halls. Through European refugee camps, along the Burma Road, across jungle battlefields of Southeast Asia, on Saipan and dozens of South Sea isles infested by stinging, biting insects, DDT spread its beneficent mist.

By the war's end, DDT had become the most publicized synthetic chemical in the world. One American newspaper clipping service accumulated nearly 21,000 items about it in an eighteen-month period in 1944-45. Most were glowingly enthusiastic; only a few questioned the unmixed blessings of DDT.

It was the questions, however, that impressed Rachel Carson.

Her career had prospered since 1936. In 1941 she had published a book, *Under the Sea Wind*, a blend of science and belleslettres which had won critical acclaim, respectable sales, and its author's appointment as editor in chief of the Fish and Wildlife Service, a post in which she could happily combine her scientific and literary interests. Her required professional reading in that post naturally included a good deal about the "miracle" insecticide. What she read disturbed her.

For instance, an experiment conducted by the U.S. Department of Agriculture's Bureau of Entomology on May 23, 1945, was reported not only in scientific journals but also in general-circulation magazines. At the rate of five pounds per acre an oil solution of DDT was sprayed over a gypsy-moth-infcsted i,2oo-acre oak forest near Moscow, Pennsylvania. It was terrifyingly effective. Every gypsymoth caterpillar in the forest died within hours. But so did every bird—at least 4,000 of them within eight days. Nor was this the limit of DDT's mischief. Annihilation of ladybug beetles by the spraying resulted in a tremendous multiplication of aphids, which are not affected by DDT but are naturally controlled by ladybugs. The forest was on the way to being completely defoliated when rains halted the outbreak; aphids are shortlived in wet weather.

In few if any other tests was the rate of DDI application as high as in the Pennsylvania oak forest. One pound per acre was found sufficient to kill gypsymoth caterpillars in a nearby forty-acre wood—a rate of application that seemed not to harm birds but was still disastrous for aquatic life, a point of special interest to Miss Carson. And when DDT in this lesser amount was sprayed over peach orchards to kill caterpillars of the Oriental fruit moth, it was found to be considerably more destructive of a parasite that attacked the moth than it was of the caterpillars themselves. In other instances, fruit trees were turned literally blood red with spiders, myriad upon myriad of them, after DDT killed the insects that normally fed on them.

Research reports noted the amazing persistence of DDT's effectiveness, due to its chemical stability and insolubility in water. Pyrethrum as then used in ordinary household sprays was highly poisonous to insects for the first few hours after application but gradually lost all power within a day or two. But DDT, sprayed upon an interior wall, was fatal to flies and mosquitoes for as long as three months; a treated mattress was a fatal resting place for bedbugs for as long as nine months; a DDT-sprayed blanket could be laundered a half dozen times, even dry-cleaned two or three times, and still kill every moth that touched it. This was an obvious advantage to the Army and Navy as well as to future civilian consumers, but among biological scientists it raised further questions as to the wisdom of releasing DDT for mass sprayings of fields and orchards, forests and pastures, city parks and tree-lined streets, year after year.

How could it be removed from sprayed fruits and vegetables since, unlike earlier poisons, it would not wash off? Would it persist and build up in soils to a level poisonous to warm-blooded animals? And just how toxic was it to such creatures, including man? Harmless to man when absorbed in small doses over the short run, might it not build up in fatty tissues (experiments with dogs in 1944 and '45 proved it *did* concentrate in fatty tissues) with harmful long-term effects? Would it be carried by soil erosion into streams and lakes and seas, with deadly effects on aquatic life? And, in general, what effect would its widespread use have upon the ecological balance?

These questions, discordant notes in the swelling anthem of praise for DDT, were all explicitly and repeatedly raised in the popular press as well as in special journals by concerned and knowledgeable men in 1944 and during the first nine months of 1945.

In early April, 1945, a report was released by the U.S. Department of Agriculture on two years of nationwide testing of DDT by department entomologists. The report spoke of DDT as a "two-edged sword," at once the "most promising insecticide ever developed" and the most menacing. Obviously a great deal more needed to be known about it before it could be deemed "safe for general use," said *Time* magazine on April 16.

Nevertheless, DDT was released for general use barely four months later. On August 31, 1945—three days before the end of World War II—the War Production Board revoked its allocation order reserving the insecticide for military use. Certification by government agencies for almost unrestricted agricultural, household, and other uses swiftly followed. The Food and Drug Administration, for example, established as "safe" a DDT content of up to 7 p.p.m. (parts per million) in foods, though no one could possibly know at that time what, if any, level was "safe" over the long run.

Once DDT was released from wartime federal controls, the government's power over its production, distribution, and use was diminished, probably more than a trusting public was aware. The U.S.D.A.'s limited control over pesticide manufacture and marketing derived from a igioact of Congress primarily intended to protect the farmer against fraud; it lacked any requirement for registering a pesticide *before* marketing it. The latter was not required until 1947, when Congress, facing a flood of chemical poisons in the wake of DDT, passed an Insecticide, Fungicide, and Rodenticide Act that incorporated and strengthened major provisions of the 1910 law. Consumer protection was broadened to include regulations for proper labelling and detailed instructions for safe use. The quintessential problem of the broad environmental effects of pesticide use was not even considered in the legislation, or in the debate preceding its passage.

In 1945 the pressures for DDT's prompt release were, of course, immense. There were great immediate profits to be made from DDT's manufacture, distribution, and agricultural use; and there was an eager market for house, yard, and other domestic uses as well. Worldwide, there was a desperate need for all the food and fiber that could be produced, and DDT could do more to increase production than any other insecticide. There was an even more desperate need to bring malaria and other insect-carried diseases under control, in our own South and in many countries (Crcece for one, India for another), and again DDT was the only available product up to the job.

For a number of years, the decision to release DDT seemed overwhelmingly justified by its benefits. The worldwide incidence of malaria was spectacularly reduced. In Greece, where a third of the work force had been losing two to three months of work time annually to malaria, and where malarial infant mortality in many villages approached 100 per cent, the disease was virtually eliminated from some 6,000 villages by a massive DDT-spraying campaign under the auspices of UNRRA, the United Nations Relief and Rehabilitation Agency. At the same time, through the use of DDT against insect pests, farm production was reportedly increased by as much as 40 per cent. In Egypt and India, equally remarkable results were achieved. It was reliably estimated that by 1950 DDT had saved five million lives over the world through destruction of malarial mosquitoes.

Millions more were saved from starvation because of increased food production made possible by DDT. The U.S.D.A. has estimated that, without chemical pesticides, some 30 per cent of America's protein supply and 80 per cent of her high-vitamin crops would be lost to insects∗—and DDT was by far the most widely and heavily used chemical pesticide through the 1950's

∗This estimate, one must note, is based on the assumption that present methods of single-crop farming over huge acreages would continue (strip-farming—dividing large fields among several different crops—would greatly reduce insect hazards) and that increasingly effective biological controls would not be developed.

Small wonder that the discoverer of DDT was honored throughout the world during the postwar years. Though he held no medical degree and had never engaged in medical research, Dr. Paul Herman Müller was awarded a Nobel Prize in Medicine for DDT in 1948. And then—at the very height of his glory—Müller dropped from public view.

Three years later, Rachel Carson became famous. In 1951 her lyric yet scientifically accurate book about the sea, *The Sea Around Us*, was published to a chorus of praise; it sold so well that, abruptly, its author became

financially independent. She resigned her government job the next year to devote herself to research and writing. Her third book, *The Edge of the Sea*, appeared in 1955, adding even more luster to her reputation and marking a transition point in her career. The concern she had first felt during the war, as she read about the wartime uses of DDT and about the field and forest tests of the "miracle" insecticide, had become a deeply felt anxiety by the time *The Edge of the Sea* was published.

She had been quick to grasp the significance of an announcement in early 1946 that U.S.D.A. entomologists had succeeded in producing, through selective breeding in a laboratory, a strain of housefly much more resistant to DI)I than the common stock. "In view of the increasing use of DDT for housefly and mosquito control," said *Science*, cautiously, on March 12, 1946, "it seems possible that, in time, a similar increase in resistance may occur under natural conditions." It had happened before, with other insecticides. And, sure enough, DDT-resistant strains of houseflies, mosquitoes, and crop-destroying insects soon began to appear naturally and in such numbers in some areas that ever more massive doses of insecticide were required to control them.

Miss Carson recognized the implications of this genetic evolution. What if DDT's effectiveness were so reduced, in the not-distant future, as to require extensive use of the even more toxic chlorinated hydrocarbons (dicldrin, aldrin, chlordane, endrin) which DDT's success had inspired? Would not these in turn lose effectiveness? No doubt chemicals still more toxic would by then be available; but what consequences would follow from their use if, indeed, they were not so lethal to men as to be unusable?

Rachel Carson, like other biologists, saw nightmare answers to these questions. The end of the process might be an environment far more hostile to man than to his insect "enemies." After all, insect generations succeed themselves hundreds of times more rapidly than human generations. If man insisted on running a genetic adaptability race with insects, he was bound to lose.

The evidence that DDT was poisoning the environment multiplied throughout the iggo's. There were increasingly frequent reports of direct poisonings of birds, of fish, of small game, sometimes after applications in excess of prescribed amounts but often, too, when the prescriptions were precisely followed.

One day in January, 1958, Olga Huckins wrote a long, eloquently angry letter to her friend Rachel Carson, describing the deadly effect of DDT spraying for mosquito control over the Huckinses' private two-acre bird sanctuary at Powder Point, in Duxbury, Massachusetts. Not long afterward Miss Carson was a house guest at Powder Point when, late in the afternoon, the spraying plane came over. The next morning she went through the estuary with the Huckinses in their boat. She was sickened by what she saw—dead and dying fish everywhere, crayfish and crabs dead or staggering as their nervous systems were destroyed. "You ought to write about this," the Huckinses kept saying. "You've *got* to...."

And Rachel Carson, publicity shy, no controversialist by temperament, acutely aware of the abuse in store for anyone who dared challenge the million-dollar pesticide industry, was forced to agree —especially as she came to realize that the direct kills were by no means the worst effect of the chemical pesticides. More widespread and disastrous by far were the delayed kills, coupled with the inhibition of reproductive processes. Entire species of birds were threatened with extinction. And how could a substance so toxic to other warm-blooded animals fail to have toxic effects, in the long run, on humans?

For as the stubbornly persistent DDT enters a food chain that begins with herbivores and runs through small to large and then larger carnivores, including man, the process known as "biological magnification" occurs. An early instance was recorded on the East Lansing campus of Michigan State University. Annual spraying of elms with DDT began there in 1954 to control the beetle that spreads Dutch elm disease. For the first year or so there were no apparent side effects. But then people noticed that there were no more robins on the campus. Earthworms feeding on elm leaves with tiny amounts of DDT on them accumulated the stuff in their body fat until a level toxic to robins was reached. Robins that ate those worms died—and robins unfortunate enough to visit the campus even two years after spraying had been discontinued also died.

In other studies the magnification rate in specific food chains was measured. In the bottom of Lake Michigan's Green Bay, for example, live billions of tiny crustaceans. The mud was found to contain 0.014 p.p.m. of DDT; the crustaceans, absorbing DDT from the mud, concentrated it in their bodies to 0.41 p.p.m.; fish, feeding on the crustaceans, concentrated DDT in their bodies to from 3 to 6 p.p.m.; herring gulls feeding on the fish accumulated DDT to the level of 99 p.p.m. This concentration, though not immediately fatal to individual gulls, reduces normal reproduction. The eggs of these herring gulls contained 227 p.p.m. of DDT, and their shells were abnormally thin.

By the late 1950's it was clear to Miss Carson, and other knowledgeable observers, that DDT's increasingly massive invasion of the food chain was largely responsible for the fact that bald eagles were ceasing to breed on the East Coast between Florida and Maine (large concentrations of DDT residues were found in the brains of prematurely dead eagles) ; that eagles in the Great Lakes region faced extinction because their egg shells were growing too thin (the physiological mechanism by which DDT inhibits calcium production would soon be discovered); that peregrine falcons were disappearing as breeding birds in the whole eastern half of the U.S.; that

ospreys would disappear from Connecticut by the early 1970's if present rates of decline continued. Nor was DDT's invasion of the food chain limited to land or to offshore waters. Oceanic food chains were being similarly contaminated, and ocean currents were spreading DDT residues to the most remote corners of the earth.

Predictable in a general way by the pattern of events was the sad case of the Bermuda petrel, a carnivorous bird that feeds solely on oceanic life far from any area where DDT is used. The bird comes to Bermuda for only a few hours, at night, to lay its eggs. It eats nothing there. Yet its eggs in the late 1960's contained 6.44 p.p.m. of DDT on the average, and its reproduction was declining at a rate which, if continued, must end in complete reproductive failure by 1978. Even Antarctica's Adélie penguins, Weddell seals, and skua gulls, carnivores all, were soon found to carry trace amounts of DDT in their fat, though they live thousands of miles from the nearest area of DDT use. Undoubtedly they ingest DDT residues in their food.

But DDT was also found, in the 1960's, in Antarctic snow,* indicating that the food chain is not the only means by which the poison spreads. Studies conducted in Maine and New Brunswick, Canada, in the 1950's showed that approximately half the DDT sprayed over forests at treetop level hung suspended in the atmosphere to be spread worldwide on the wind. DDT attached to erosion debris also travels in irrigation water, rivers, and ocean currents.

*Some 2,400 tons of it have been estimated to have accumulated by now in Antarctica's snows.

The realization that the oceans' organisms are becoming depositories for DDT has led some ecologists to premonitions of an apocalypse, based on the assumption that much of the oxygen in the atmosphere is produced through photosynthesis by marine phytoplankton (vegetable life). Hence, anything that might inhibit oceanic photosynthesis on a large scale is a threat to life on earth.

Scientists of this persuasion took little comfort in the 1968 report by Charles F. Wurster, Jr., of the State University of New York at Stony Brook; in the laboratory very low concentrations of DDT had measurably reduced photosynthesis in cultures of four species of coastal and oceanic phytoplankton representing four major classes of algae. Furthermore, the same had been found true of a natural phytoplankton community (as distinct from a laboratory culture) at Woods Hole. "I'll tell you what we worry about most," said David M. Gates, director of the Missouri Botanical Garden in St. Louis, to a reporter in 1969, "—an irreversible catastrophe. A number of pesticide spills, for example, in those areas of the ocean where … much of the world's oxygen [is produced]. If you plot the frequency of this kind of event, they're getting closer and closer." Much of this kind of fear has been allayed by recent scientific findings that suggest that no significant interchange of oxygen occurs between ocean and atmosphere, and, in addition, that some phytoplankton are considerably less sensitive to pesticides than others. Such findings, of course, do not alter the fact that any large-scale interference with ocean life would have serious repercussions.

Whatever its ultimate effects may be, the frightening fact is that most of the hundreds of millions of pounds of DDT sprayed over the world during the last quarter century remain in circulation- only a fraction has decayed into harmless substances—and no one can say what fatal damage it alone (apart from the DDT being constantly added) may yet do.

Credit for the fact that public, governmental, and scientific attention was focused on the threat of DDT and other chemicals in the environment must certainly go to Rachel Carson's *Silent Spring*. Researching it meticulously (her argument was sustained by no fewer than fifty pages of closely printed source notes), she wrote the book in longhand, slowly, most of it in her home in Silver Spring, Maryland, and much of it at night, over a period of nearly four years, beginning in 1958. She well knew that her warning of the threat to the environment from the indiscriminate use of ever more and stronger pesticides would provoke attacks upon her motives, professional competence, and "scientific objectivity"; and so she was not surprised by the storm of controversy her book aroused even before its formal publication date in 1962. But with scientific colleagues, with the general public, and with many governmental policy makers, *Silent Spring* was enormously persuasive.

One of Rachel Carson's central points was that man, like every living thing, is a creature of his environment, and, consequently, any chemical fatal to his environment must ultimately be fatal to him (a concept commonly understood today but new to many a decade ago). She also challenged the constantly reiterated assertion that DDT and its close chemical affiliates are not directly toxic to human beings.

True, most Americans now probably have 10 to 12 p.p.m. DDT in their body fats, which is 3 to 5 p.p.m. more than the F.D.A.-set tolerance level for human food; and we seem unharmed by it. But what of the effects that may not show up for two or three decades or generations? Is DDT damaging chromosome structure? Is it, through subtle attacks on the central nervous system, slowly impairing mental processes? Is it a carcinogen (cancer-inducing agent)? Rachel Carson cited disturbing evidence that the answer to such questions might be affirmative.

Today DDT is increasingly suspected of direct injury to man. Evidence of the carcinogenic effects of DDT have multiplied since 1962. Indeed, in the very year following publication of *Silent Spring*, Dr. William C. H. Hueper of the National Cancer Institute reported DDT to be "cancer producing according to presently available evidence"

and incriminated DDT in the "production of benign and malignant tumors of the liver, cancers of the lung, and leukemias."

Two years after her best seller was published—in mid-April, 1964—Rachel Carson, aged fifty-six, died of cancer. (Dr. Paul Müller died in October of the following year, at the age of sixty-six.) But before she died she had the satisfaction of knowing that her work was influencing public policy.

In 1963, in direct response to the public concern aroused by *Silent Spring*, President Kennedy's Science Advisory Committee recommended a reduction of DDT use with a view to its total elimination as quickly as possible, along with other "hard" pesticides. Soon thereafter Secretary of the Interior Stewart Udall issued an order banning the use of DDT on Interior-controlled lands "when other chemicals can do the job." Wisconsin, Michigan, California, Massachusetts, and other states began to move toward state prohibitions of DDT. Finally, in November of 1969, acting on the recommendation of a special study commission on pesticides, Robert H. Finch, Secretary of Health, Education, and Welfare, announced that the federal government would "phase out" all but "essential uses" of DDT within two years. Many Americans assumed that this phasing out means the end of DDT. But not so.

Even though, belatedly, the search has been intensified for safe alternatives to persistent pesticides, the worldwide demand for DDT increases as underdeveloped countries face the immediate desperate problems of feeding and protecting the health of exploding populations. The U.N.'s World Health Organization and the Food and Agricultural Organization have strongly opposed any prohibition or even reduction of DDT's use, arguing that it is the cheapest effective pesticide (it costs about fifteen cents a pound as compared with a dollar or more for other chemicals), that poor countries cannot afford substitutes, and that without the kind of crop protection and disease control provided by DDT, millions must surely and quickly die. In India, for instance, U.N. consultants are now working with the government to *double* within a year the percentage of cropland sprayed by hard pesticides, chiefly DDT. Even in America the government has moved so slowly to implement its "phase out" policy that citizen conservation groups, led by the crusading Environmental Defense Fund, have taken action to stop the manufacture and use of DDT through legal suits against government agencies and the major manufacturer.

And so the use of DDT continues, even as its disastrous effects on living things are being established beyond any doubt. The need for some system of broadly assessing the likely consequences of technological innovations before they are unleashed seems all too apparent. In the case of DDT, however, we can only hope to live with our mistakes.

Mr. Dams, a frequent writer on conservation subjects, is now writing a biography of Franklin D. Roosevelt to be published by G. P. Putnam 's Sons.